Environmental Functional Area

Water, Air, Monitoring & Analysis

UCRL-AR-132057-12-2

Lawrence Livermore National Laboratory (LLNL) Experimental Test Site (Site 300)

Compliance Monitoring Program for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)-Closed Pit 6 Landfill

Second Quarter Report for 2012

Authors

Richard G. Blake
John E. Valett

Lawrence Livermore National Laboratory

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Summary

This monitoring report is required by the *Post-Closure Plan for the Pit 6 Landfill Operable Unit, Lawrence Livermore National Laboratory, Site 300* (Ferry et al*.*, 1998). It summarizes post-closure compliance activities performed at the closed Pit 6 landfill during the second quarter of 2012. Compliance requirements for Pit 6 are also described in *Compliance Monitoring Plan/Contingency Plan for Environmental Restoration at Lawrence Livermore National Laboratory, Site 300* (Dibley et al., 2009) and the *Site-Wide Record of Decision for Lawrence Livermore National Laboratory, Site 300* (U.S. DOE, 2008). Results from quantitative analyses by state-certified analytical laboratories of chemical constituents of concern in ground water samples are summarized in the report and listed in the appendices.

Constituents of concern measurements made during the second quarter of 2012 did not differ significantly from past quarters. Tritium exceeded its statistical limits (SLs) in one downgradient detection monitoring program (DMP) well and all other constituents of concern were below the SLs. SLs for tritium were previously exceeded in samples collected from some ground water wells near the Pit 6 landfill. These elevated tritium activities have been previously reported to the Central Valley Regional Water Quality Control Board (CVRWQCB). As stated in previous reports, it appears that the elevated tritium concentrations detected in ground water samples at Pit 6 are related to past releases from the landfill prior to its closure in 1997.

On May 2, 2012, the annual Pit 6 engineering inspection was performed by an independent contractor, Abri Engineering. This annual inspection noted that the pit cap and drainage structures continue to function properly, and the vegetation cover and drainage systems are in proper operating condition.

In July 2012, DOE/LLNL proposed and the regulatory agencies agreed to modify the detection monitoring and reporting program for the Pit 6 Landfill for consistency with the Detection Monitoring Program in the CERCLA Site-Wide Compliance Monitoring Plan. As part of these regulatory-accepted changes, the U.S. Environmental Protection Agency, the California Department of Toxic Substances Control, and the Central Valley Regional Water Quality Control Board agreed that DOE/LLNL no longer needed to submit these quarterly Pit 6 Post-Closure Monitoring Report to eliminate redundancies with reporting in the semi-annual and annual Compliance Monitoring Reports. As a result, the regulators have concurred that this 2nd Quarter 2012 report will be the last quarterly report submitted for the Pit 6 Landfill. Pit 6 detection and corrective action monitoring results for the second semester of 2012 will be reported in the Annual 2012 Compliance Monitoring Report. Pit 6 detection and corrective action monitoring results in 2013 and thereafter will be reported in the Semi-Annual and Annual Compliance Monitoring Reports.

DOE/LLNL will submit an Addendum to the Compliance Monitoring Plan to incorporate the Pit 6 Detection Monitoring and Reporting Program, which will supercede the 1998 Post-Closure Monitoring Plan.

Introduction

Site 300 is the LLNL Experimental Test Facility located in the Altamont Hills approximately 10.5 kilometers (km) (6.5 miles [mi]) southwest of downtown Tracy, California (**Figure 1**). Site 300 is owned by the United States Department of Energy (U.S. DOE) and is an approximately 28.3 km^2 (10.9 mi^2) area site operated by Lawrence Livermore National Security, LLC. The closed Pit 6 landfill is located within Site 300 near its southern boundary (**Figure 2**). A post-closure plan requiring quarterly and annual reports of compliance monitoring activities at the Pit 6 landfill (Ferry et al., 1998) was implemented during the second quarter of 1998.

Figure 1. Location of LLNL Site 300.

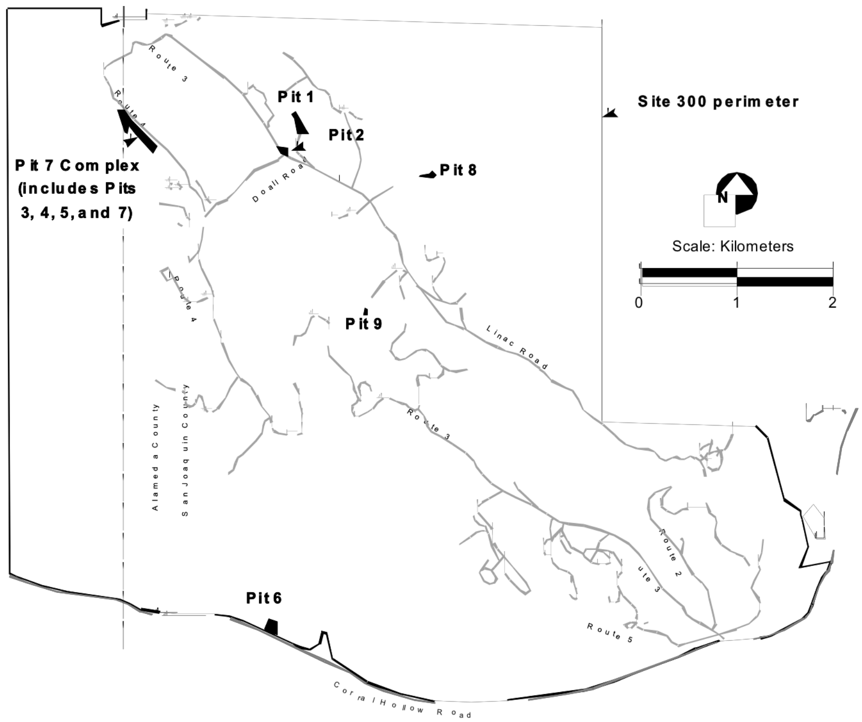

Figure 2. Location of Pit 6 at LLNL Site 300.

Figure 3 shows the locations of the wells that are used to monitor the ground water in the vicinity of the Pit 6 landfill, including upgradient wells, detection monitoring wells, and corrective action monitoring wells (Ferry et al*.,* 1998). The northern limit of the Carnegie-Corral Hollow Fault zone extends beneath Pit 6 as shown in **Figure 3**. Ground water flows southeastward, following the inclination (dip) of the underlying sedimentary rocks. Depth to the water table ranges from 10 to 20 meters (m) or 33 to 66 feet (ft) in terrace deposit gravels within the fault zone beneath Pit 6. Ground water flows within these gravels to the east-southeast, parallel to the Site 300 boundary fence line (Webster-Scholten, 1994).

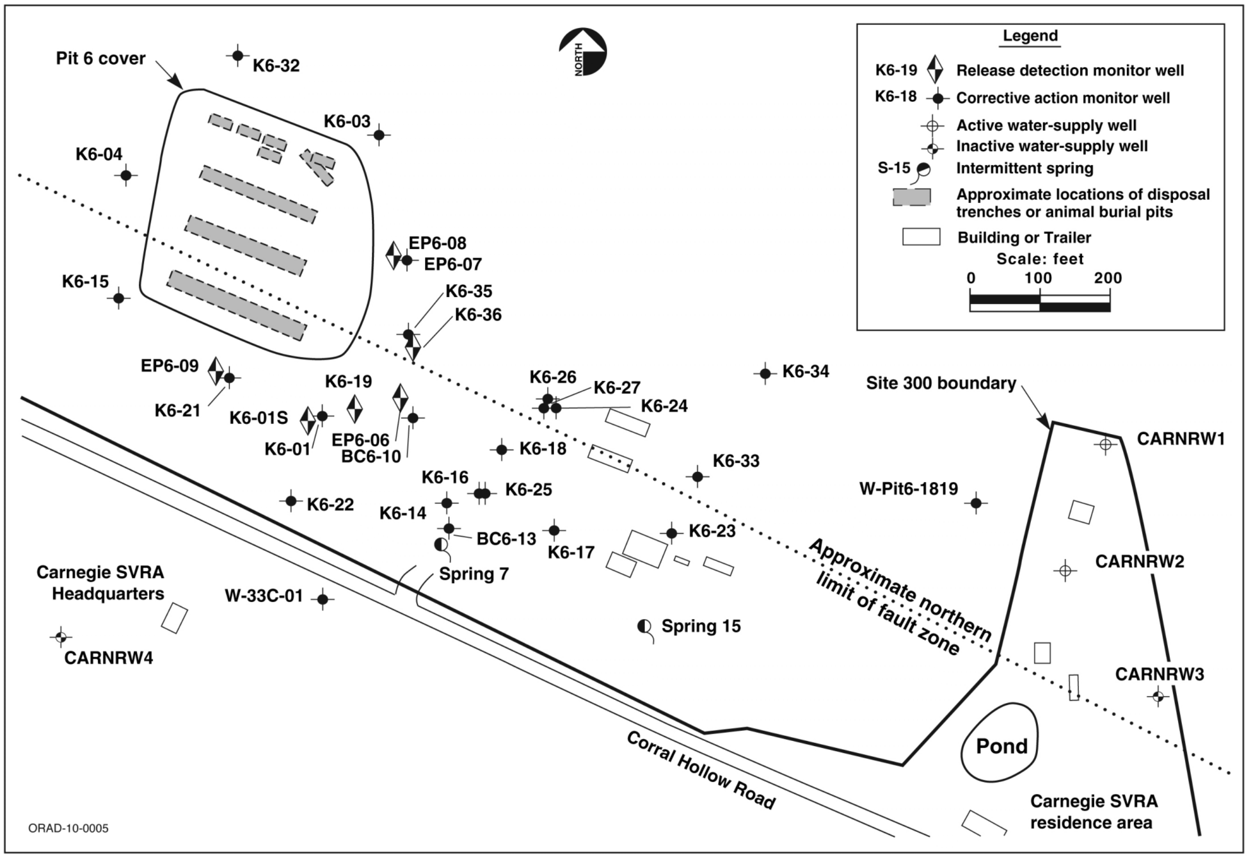

Figure 3. Locations of Pit 6 monitoring wells.

Monitoring Program Overview

The primary post-closure monitoring activity performed by LLNL at the Pit 6 landfill is the collection of ground water samples for chemical and radioisotope analysis. Two ground water monitoring programs have been implemented at the Pit 6 landfill to ensure compliance with regulations. The Detection Monitoring Program (DMP) detects any new releases of constituents of concern to ground water from wastes buried in the landfill. Constituents of concern, as defined by Title 23 of the California Code of Regulations (CCR), Chapter 15, are waste constituents, reaction products, and hazardous constituents that are reasonably expected to be in or derived from waste buried in the Pit 6 landfill. Twenty-four constituents of concern, including volatile organic compounds (VOCs) and radioisotopes, were identified for monitoring under the DMP in the Pit 6 Post-Closure Plan (Ferry et al., 1998). A select set of DMP wells are monitored quarterly for constituents of concern in compliance with the Pit 6 Post-Closure Plan (**Figure 3**). Field measurements of ground water physical parameters are collected at the time of sampling.

The Corrective Action Monitoring Plan (CAMP) monitors movement of historically-released contaminants of concern in ground water. Contaminants of concern are anthropogenic chemicals, metals, radionuclides, or other substances detected in environmental media that pose a risk to human or ecological receptors or a threat to ground water. VOCs and tritium were identified at the Pit 6 landfill as ground water contaminants of concern for monitoring under the CAMP. CAMP wells are monitored at least annually in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Compliance Monitoring Plan (Dibley et al., 2009).

Perchlorate and nitrate were detected in ground water near Pit 6 during CERCLA site-wide surveys subsequent to the Pit 6 Post-Closure Plan. Perchlorate was added to the list of constituents of concern to be monitored under the DMP. Since January 2003, nitrate and perchlorate were added as contaminants of concern to be monitored in an expanded set of CAMP wells (**Figure 3**). Additional changes to the monitoring program implemented since January 2003 are discussed in **Appendix D**.

As required by Executive Order 12770, our measurements are reported in *Système Internationale* (SI) units. The SI unit for radioactivity is the becquerel (Bq), equal to 1 nuclear disintegration per second. The more commonly used unit, the picocurie (pCi), is equal to 1 nuclear disintegration per 27 seconds. As a convenience, maximum contaminant levels (MCLs) for radioactivity in drinking water are given in both becquerels per liter (Bq/L) and picocuries per liter (pCi/L) in **Table 1**, below. Note that MCLs are provided for reference only.

Table 1. MCLs for radioactivity in drinking water.

Radiological parameter	**MCL** (Bq/L)	**MCL** (pCi/L)
Gross alpha	0.555	15
Gross beta	1.85	50
Tritium	740	20,000
Uranium (total)	0.74	20

DMP Objective

The primary DMP objective is to detect any new release of constituents of concern to ground water. Ground water is sampled quarterly from six wells located hydraulically downgradient of Pit 6 along the point of compliance. These wells are identified as EP6-06, EP6-08, EP6-09, K6-01S (K6-01 if K6-01S is dry), K6-19, and K6-36 in **Figure 3**. Water samples are sent to state-certified laboratories where they are analyzed quantitatively for the presence (or absence) of constituents of concern (see **Table C-1** for the list of DMP constituents of concern). Gross alpha and gross beta radioactivity measurements are used as surrogates for seven radionuclide constituents of concern other than uranium and tritium. Additional field measurements of ground water general parameters are obtained quarterly at the time of sample collection.

Potential releases of constituents of concern from Pit 6 are indicated by comparing analytical results for ground water samples with statistically-determined limits of concentration, called statistical limits, or SLs (see **Appendix C**, **Table C-1**, for the list of constituents of concern and their respective SLs). If a constituent of concern measurement exceeds a SL, the measurement is investigated further to determine its validity. Consistent with state regulations, two independent ground water samples, called retest samples, are obtained from the associated monitoring well at least one week apart and analyzed for the suspect constituents of concern. If the constituent of concern is present in either sample at a concentration that exceeds the SL, then the initial analysis is deemed to be valid and it is reported as statistically significant evidence of a release. If neither retest sample measurement exceeds the SL, then the initial exceedance is not confirmed, and a release report is not made. Any further investigation of a constituent of concern is at the discretion of the Site 300 Remedial Project Managers (RPMs) and is conducted by LLNL under CERCLA.

CAMP Objectives

The primary CAMP objectives are to: (1) evaluate the effectiveness of the corrective action; (2) evaluate natural attenuation of the ground water VOC and tritium plumes; (3) monitor perchlorate and nitrate in ground water; and (4) evaluate the need for implementing contingency actions. To accomplish the CAMP objectives, ground water samples are collected from the monitoring wells shown in **Figure 3** at least annually and analyzed for the CERCLA contaminants of concern (VOCs, tritium, perchlorate, and nitrate) and water levels are measured quarterly as specified in the CERCLA Compliance Monitoring Plan.

The Pit 6 landfill received waste from 1964 through 1973 and the pit was officially closed when an engineered cap was constructed at the site in the summer of 1997, and followed by the Final Post Closure Plan in May 1998 (Ferry et al., 1998). Several VOCs, tritium, and perchlorate were released to ground water from Pit 6 prior to its capping and closure. Nitrate has also been detected in ground water at concentrations that exceed drinking water standards. Contaminants of concern in Pit 6 ground water have been described and evaluated previously in the *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory, Site 300* (Webster-Scholten, 1994), the *Final Feasibility Study for the Pit 6 Operable Unit, Lawrence Livermore National Laboratory, Site 300* (Devany et al., 1994), the *Addendum to the Pit 6 Engineering Evaluation/Cost Analysis, Lawrence Livermore National Laboratory, Site 300* (Berry, 1996), and the *Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory, Site 300* (Ferry et al., 1999). The selected CERCLA clean-up remedy for the Pit 6 landfill is described in the *Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory, Site 300* (U.S. DOE, 2001) and the *Site-Wide Record of Decision for Lawrence Livermore National Laboratory, Site 300* (U.S. DOE, 2008).

The engineered cap is in place to prevent further releases from Pit 6. Monitored natural attenuation is the remedial action selected for tritium and VOCs in Pit 6 ground water in the Site-Wide Record of Decision. Due to the limited extent of perchlorate and nitrate in Pit 6 ground water, a monitoring-only remedy was selected in the Site-Wide Record of Decision. Ground water monitoring is conducted to evaluate the effectiveness of the remedial action and to ensure there is no impact to downgradient water-supply wells.

Additional post-closure activities for Pit 6 include: (1) inspection of the landfill cap by LLNL technical staff annually and following major storms; (2) an annual comprehensive inspection of the landfill by an independent state-certified Professional Engineer (PE); (3) an annual pit cap elevation survey; (4) repairs as necessary to maintain the integrity of the landfill cap, its water diversion system, and its network of monitoring wells; and (5) preparation of reports. Reports of post-closure activities are provided to the participating regulatory agencies for their information and use.

Quality Assurance

To ensure data quality, LLNL works within the established Quality Assurance (QA) program of the LLNL Environmental Restoration Department (ERD). LLNL uses protocols and procedures that cover all aspects of ground water sampling, sample tracking, and data management. These written protocols and procedures are contained in the *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)* (Goodrich and Lorega, 2009), and the *Environmental Monitoring Plan* (Gallegos, 2012). Data quality is assessed by the following four methods: (1) analytical results for the routine and duplicate samples are compared by the analysts responsible for this report; (2) field blank samples are submitted to the analytical laboratories together with the routine ground water samples for identical analyses; (3) equipment blanks are prepared and analyzed to ensure that sampling equipment is properly cleaned before use; and (4) when samples are collected for VOC analysis, a trip blank (prepared at the analytical laboratory) is carried into the field. A summary of QA results may be found in **Appendix E, Table E-1**.

DMP Summary for the Second Quarter 2012

This section summarizes the monitoring results for DMP constituents of concern. Constituents of concern measurements for the DMP wells are listed in **Appendix A, Table A-1**. Field measurements of ground water parameters and analytical laboratory measurements of total dissolved solids (TDS) for the DMP wells are listed in **Appendix A, Table A-2**. Data collected during the second quarter of 2012 do not differ significantly from the past quarter (see Blake and Valett, 2012). Wells K6-36 and EP6-08 again were either dry or contained insufficient water to collect samples this quarter.

Tritium and VOCs that were released to ground water from the landfill prior to its closure in 1998 continue to be detected (**Table A-1**). Tritium activities continued to exceed the SL of 3.7 Bq/L (100 pCi/L) in ground water samples from one downgradient DMP well (K6-19) during the second quarter of 2012 from a routine sample (8.5 Bq/L [229 pCi/L]). Tritium activity in this well is higher than the level reported last quarter K6-19 (9.3 Bq/L [251 pCi/L]). Historically, tritium activities in well K6-19 have dropped since September 1999 from the maximum of 93 Bq/L (2520 pCi/L). Since then, tritium activities have decreased (Campbell, 2007; Blake et al., 2011) and have always been well below the U.S. Environmental Protection Agency (EPA) drinking water MCL of 740 Bq/L (20,000 pCi/L).

The VOCs detected in Pit 6 DMP wells, including trichloroethene (TCE), were not detected at concentrations greater than the SL in any ground water samples collected during the second quarter of 2012 (**Table A-1**).

CAMP Summary for the Second Quarter 2012

This section summarizes an analysis of ground water elevation and contaminant of concern data collected as part of the CAMP monitoring during the second quarter of 2012. The primary CERCLA contaminants of concern for the Pit 6 area are several VOCs and tritium (Ferry et al., 1998). Perchlorate and nitrate were subsequently detected at concentrations above the State MCL for drinking water in ground water samples from several Pit 6 monitoring wells during site-wide investigations by LLNL. Perchlorate was designated a secondary contaminant of concern in 2000. Beginning in 2003, nitrate also became a secondary contaminant of concern. Ground water elevations for the second quarter of 2012 are listed in **Table B-1.** Concentrations of VOCs detected in ground water samples collected during the second quarter are listed in **Table B-2.** Tritium results for all ground water samples collected during the second quarter are listed in **Table B-3**. Perchlorate and nitrate results for all ground water samples collected during the second quarter are listed in **Table B-4.** Ground water elevation and VOC, tritium, perchlorate, and nitrate data are discussed in the following sections.

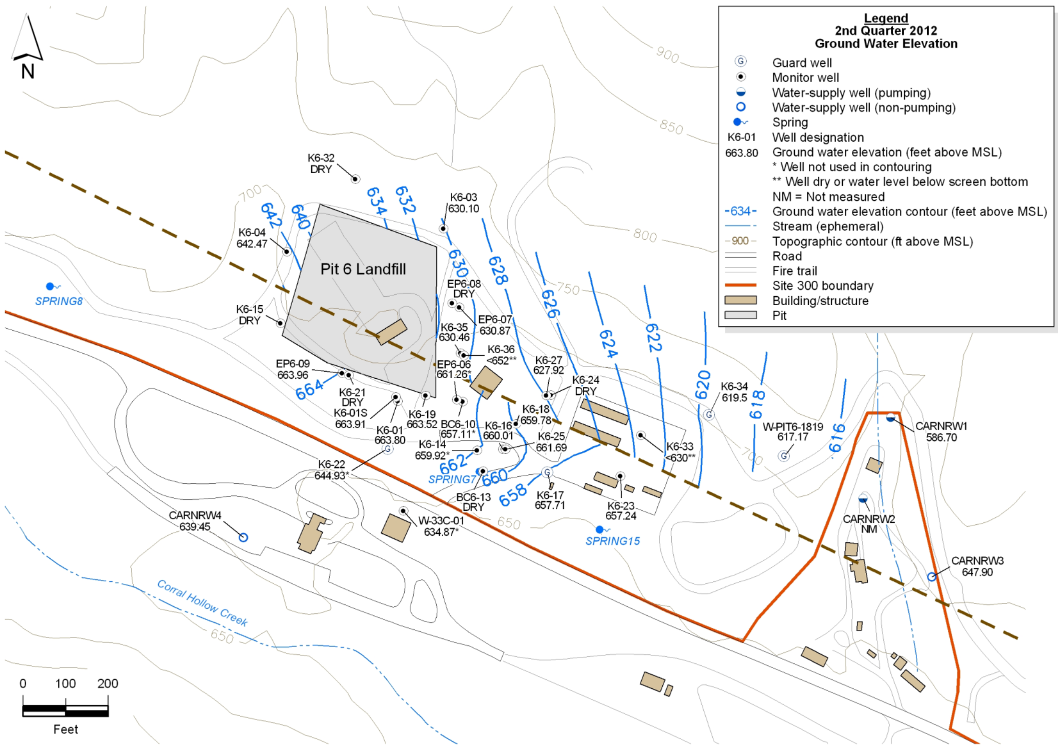

Figure 4. Ground water elevations (ft above MSL) in the first water-bearing zone at Site 300 Pit 6, second quarter 2012.

Ground water elevations (GWE). Figure 4 is a ground water elevation contour map for the second quarter of 2012. Ground water elevations beneath Pit 6 are approximately 12 m (40 ft) below the buried waste trenches. Ground water elevations within the fault zone and immediately south of Pit 6 were similar to last quarter's. In general, water elevations north of the fault zone were an average of about six feet lower than last quarter's.

The predominantly southeast flow direction shown on **Figure 4** is consistent with potentiometric surface maps from previous quarters. Within the fault zone, ground water flows to the southeast with a hydraulic gradient of approximately 0.03. North of the fault zone, ground water flows to the southeast with a hydraulic gradient of approximately 0.01–0.02. Fractures in the Neroly Formation Tnbs$_1$ stratigraphic unit play a dominant role in conveying ground water flow. Generally, throughout the year, a large component of the flow north of the fault is affected by pumping from offsite water-supply wells CARNRW1 or CARNRW2. However, ground water elevations to the south, within the fault zone, do not appear to be strongly influenced by pumping. During the second quarter of 2012, routine water levels for the CARNRW wells were measured on June 5th 2012; whereas the Pit 6 monitoring well water levels were measured on June 11th, 2012. The ground water elevation contours shown on **Figure 4** represent conditions on June 5th (non-pumping at CARNRW1 as indicated by available second quarter 2012 transducer data), although the quarterly posted elevation for CARNRW1 (June 11th) represents a pumping elevation.

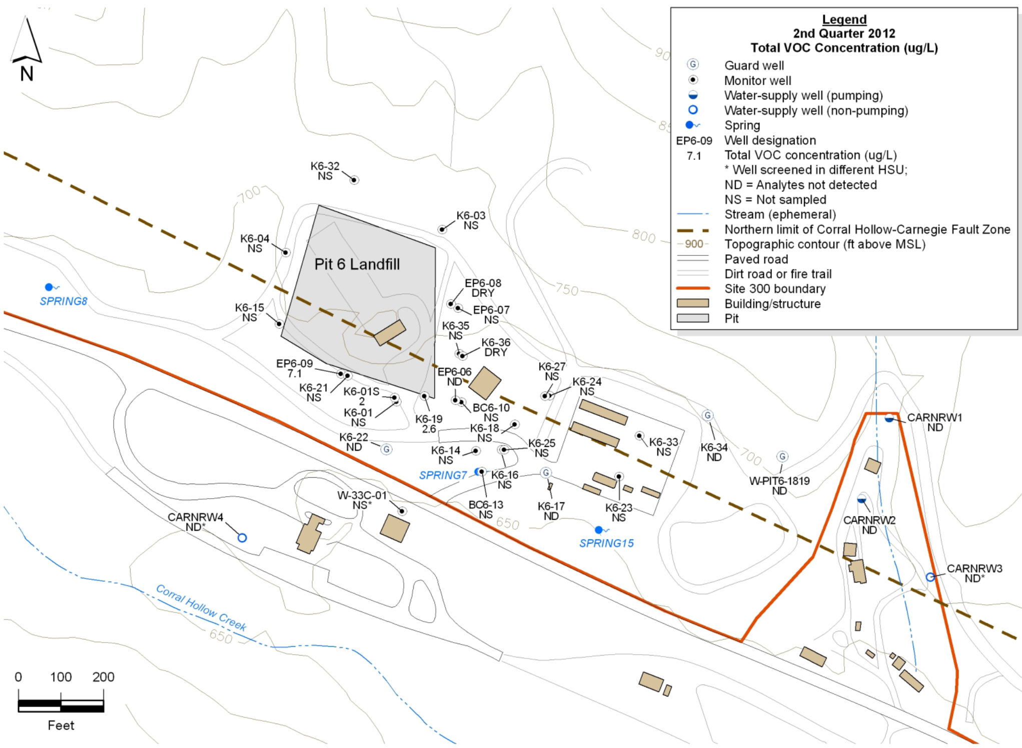

Figure 5. Ground water TVOC concentrations (µg/L) in the first water-bearing zone at Site 300 Pit 6, second quarter 2012.

Ground water VOC concentrations. Figure 5 presents the distribution of total VOC (TVOC) concentrations for the shallow water-bearing zone wells sampled during the second quarter of 2012. Less than half of the wells at Pit 6 are sampled during the second quarter (first and third are the primary sampling quarters), and therefore, VOC concentrations are not contoured for this quarter. Fourteen VOC concentrations are summed for the calculation of TVOC. The concentrations of individual VOCs in ground water samples detected during the second quarter of 2012 are listed in **Table B-2**. TVOC concentrations detected during the second quarter of 2012 were similar to those detected during the first quarter of 2012. During the second quarter of 2012, VOCs were detected in samples from three ground water monitor wells in the Pit 6 area (EP6-09, K6-01S, and K6-19). TVOC concentrations in Pit 6 ground water have decreased from a historical maximum of 253 μg/L in 1988 to a maximum of 7.1 μg/L in the second quarter of 2012. This quarter, TCE and cis-1,2-DCE were the only VOCs detected in Pit 6 ground water samples.

The maximum TVOC concentrations this quarter were detected in samples collected from well EP6-09 (6.8 μg/L from a routine sample, and 7.1 μg/L from a duplicate sample). TCE was the only VOC detected in these samples. This represents a slight decrease from the first quarter 2012 concentration in well EP6-09 of 8.7 μg/L and a general decrease in TCE concentrations in well EP6-09 from the historical maximum concentration of 28 μg/L (1995).

Cis-1,2-DCE continues to be detected in well K6-01S ground water. Concentrations of cis-1,2-DCE have decreased from a historical maximum of 9.8 μg/L in 1992 to 2.0 μg/L in the second quarter of 2012, below the 6 μg/L cis-1,2-DCE MCL. The presence of cis-1,2-DCE, a degradation product of TCE, suggests that natural decomposition may be occurring. Cis-1,2-DCE was not detected above the 0.5 μg/L reporting limit in samples from any other Pit 6 wells in the second quarter of 2012.

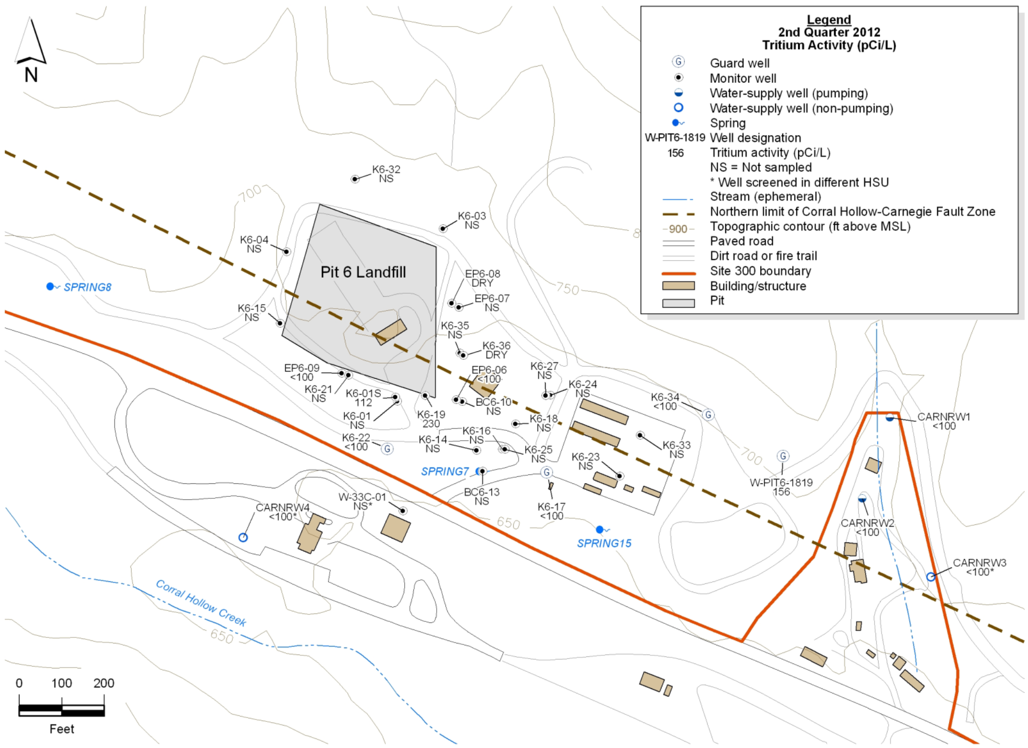

Figure 6. Ground water tritium activities (pCi/L) in the first water-bearing zone at Site 300 Pit 6, second quarter 2012.

Ground water tritium activity. Figure 6 presents the distribution of tritium activities for the shallow water-bearing zone wells sampled during the second quarter of 2012. Less than half the wells at Pit 6 are sampled during second quarter (first and third are the primary sampling quarters), and therefore, tritium activities are not contoured during this quarter. The tritium activities in ground water from all wells sampled during the second quarter of 2012 are listed in **Table B-3**. Tritium activities detected during the second quarter of 2012 were similar to those detected during the first quarter of 2012. This quarter, tritium activities in the first water bearing zone north of the fault zone in excess of the 3.7 Bq/L (100 pCi/L) detection limit were found in one ground water sample, from W-PIT6-1819, at 5.8 Bq/L (156 pCi/L). Prior to the second quarter of 2012, tritium activities in W-PIT6-1819 ground water ranged from < 100 pCi/L to 295 pCi/L. This quarter, within the fault zone, tritium was detected in the first water-bearing zone in samples from two wells, K6-19, at 8.5 Bq/L (230 pCi/L) and K6-01S, at 4.1 Bq/L (112 pCi/L).

Tritium was not detected at or above the 740 Bq/L (20,000 pCi/L) MCL or the 14.8 Bq/L (400 pCi/L) State PHG in samples from any wells in the Pit 6 area. Tritium activities were below the detection level of 3.7 Bq/L (100 pCi/L) in the monthly ground water samples obtained during the second quarter of 2012 from the off-site CARNRW wells.

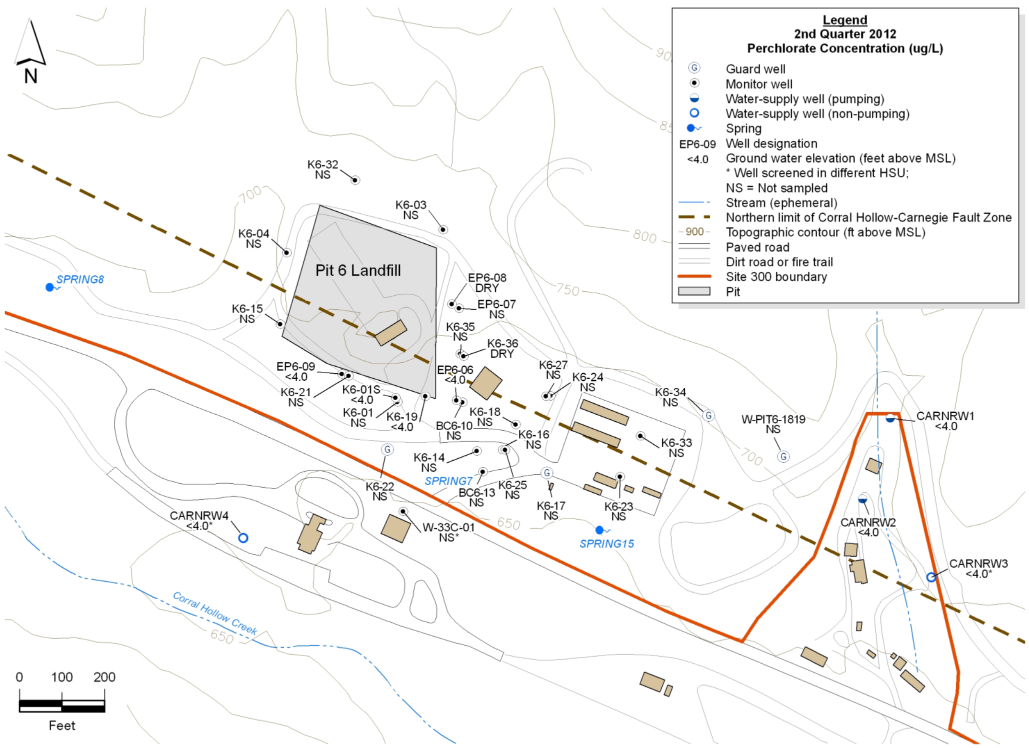

Figure 7. Ground water perchlorate concentrations (µg/L) in the first water-bearing zone at Site 300 Pit 6, second quarter 2012.

Ground water perchlorate concentrations. A map showing second quarter 2012 perchlorate concentrations in ground water samples collected from the shallow water-bearing zone is presented in **Figure 7**. Ground water perchlorate data for the second quarter of 2012 are listed in **Table B-4**. During the second quarter of 2012, perchlorate was not detected in any Pit 6 samples at concentrations above the 4 µg/L detection limit. Perchlorate concentrations in Pit 6 ground water have decreased significantly from the historical maximum of 65 µg/L in 1998.

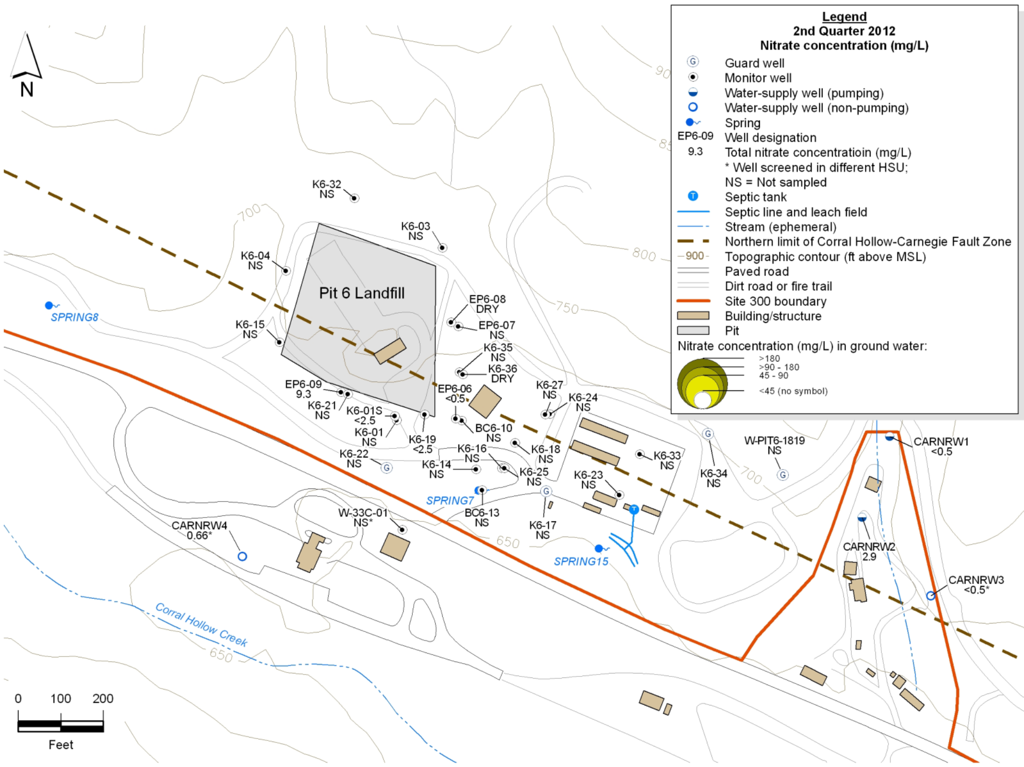

Figure 8. Ground water nitrate concentrations (mg/L) in the first water-bearing zone at Site 300 Pit 6, second quarter 2012.

Ground water nitrate concentrations. A map showing second quarter 2012 nitrate concentrations in the shallow water-bearing zone at Pit 6 is presented in **Figure 8**. Ground water nitrate data for the second quarter of 2012 are listed in **Table B-4**. During the second quarter of 2012, nitrate was not detected above the 45 milligram per liter (mg/L) MCL in samples from any wells in the Pit 6 area. Well K6-23 has historically yielded nitrate concentrations above the MCL; however, this well was not sampled this quarter (typically sampled first and third quarters). Last quarter (first quarter 2012), K6-23 yielded a nitrate concentration of 150 mg/L, below the 228 mg/L historical maximum nitrate concentration detected in this well at Pit 6. Well K6-23 is located adjacent to the Building 899 septic system, which is a potential source of the nitrate. The maximum second quarter 2012 nitrate concentration in monthly samples from the four CARNRW offsite water-supply wells (CARNRW1, CARNRW2, CARNRW3, and CARNRW4) was 2.9 mg/L in the May 2012 sample from CARNRW2.

Inspection and Maintenance Summary

On May 2, 2012, the annual Pit 6 engineering inspection was performed by an independent contractor, Abri Engineering (**Appendix F**). This annual inspection noted that the pit cap and drainage structures continue to function properly, and the vegetation cover and drainage systems are in proper operating condition. A few maintenance suggestions are noted such as removal of minor vegetation debris from the drainage ditch as well as suggested filling of several small animal burrows that are greater than six inches in diameter. All of these minor repairs have been completed by LLNL staff.

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Acknowledgments

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Abbreviations and Acronyms

Bq	becquerel (international unit of radioactivity equal to 27 pCi)
CAMP	Corrective Action Monitoring Program
CCR	California Code of Regulations
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Cis-1,2-DCE	Cis-1,2-dichloroethene
CL	concentration limit (background concentration of a chemical)
CVRWQCB	Central Valley Regional Water Quality Control Board
DMP	Detection Monitoring Program
DOE	U.S. Department of Energy
DTSC	California Department of Toxic Substances Control
DUP	duplicate sample
EPA	U.S. Environmental Protection Agency
ERD	LLNL Environmental Restoration Department
ft	foot (used as a measure of elevation above MSL)
GWE	ground water elevation in feet above MSL
km	kilometer
km^2	square kilometer
L	liter
LLNL	Lawrence Livermore National Laboratory
m	meter
m^2	square meter
MCL	maximum contaminant level (for drinking water)
MSL	mean sea level (datum for elevation measurements)
mg	milligram
µg	microgram
pCi	picocurie (unit of radioactivity)
PHG	California State Public Health Goal (PHG)
PE	Professional Engineer
QA	quality assurance
RL	reporting limit (contractual concentration near zero)
RPM	remedial project manager
RTN	routine sample

Site 300	Experimental Test Site, LLNL
SL	Statistically-determined concentration limit
SOP	standard operating procedure
TCE	trichloroethene
TDS	total dissolved solids
$Tnbs_1$	Neroly Formation lower blue sandstone unit
VOC	volatile organic compound
yr	year

Appendix A

Tables of Ground Water Measurements for Detection Monitoring Wells

Table A-1. Pit 6 post-closure monitoring plan constituents of concern, detection monitoring wells, SLs, MCLs, and quarterly analytical results for 2012.

COC (units)	Well	SL	MCL	Quarter First	Quarter Second	Quarter Third	Quarter Fourth
Metals (µg/L)							
Beryllium	EP6-06	0.2	4	<0.2	<0.2		
	EP6-09	0.2		<0.2	<0.2		
	K6-01S	0.2		<0.2	<0.4		
	K6-19	0.2		<0.2	<0.2		
Mercury	EP6-06	0.2	2	<0.2	<0.2		
	EP6-09	0.2		<0.2	<0.2		
	K6-01S	0.2		<0.2	<0.2		
	K6-19	0.2		<0.2	<0.2		
Radioactivity (Bq/L)							
Tritium	EP6-06	3.7	740	1.1	2.1		
	EP6-09	3.7		0.47	0.71		
	K6-01S	3.7		1.2	4.1		
	K6-19	3.7		9.3	8.5		
Uranium (total)	EP6-06	0.13	0.74	0.02	0.02		
	EP6-09	0.14		0.1	0.06		
	K6-01S	1.00		0.18	0.16		
	K6-19	0.27		0.13	0.10		
Gross alpha	EP6-06	0.28	0.55	0.07	0.03		
	EP6-09	0.18		0.14	0.09		
	K6-01S	0.96		0.29	0.37		
	K6-19	0.34		0.12	0.18		
Gross beta	EP6-06	0.79	1.85	0.26	0.26		
	EP6-09	0.79		0.42	0.39		
	K6-01S	2.13		0.78	0.62		
	K6-19	0.79		0.35	0.30		
Volatile organic compounds (µg/L, EPA method 8260)							
Benzene	EP6-06	0.5	1	<0.5	<0.5		
	EP6-09	0.5		<0.5	<0.5		
	K6-01S	0.5		<0.5	<0.5		
	K6-19	0.5		<0.5	<0.5		
Carbon disulfide	EP6-06	5	none	<5	<5		
	EP6-09	5		<5	<5		
	K6-01S	5		<5	<5		
	K6-19	5		<5	<5		
Chloroform	EP6-06	0.5	80	<0.5	<0.5		
	EP6-09	0.5		<0.5	<0.5		
	K6-01S	0.5		<0.5	<0.5		
	K6-19	1.5		<0.5	<0.5		
1,2-dichloroethane	EP6-06	0.5	0.5	<0.5	<0.5		
	EP6-09	0.5		<0.5	<0.5		
	K6-01S	0.5		<0.5	<0.5		
	K6-19	0.5		<0.5	<0.5		
Cis-1,2-dichloroethene	EP6-06	0.5	6	<0.5	<0.5		
	EP6-09	0.5		<0.5	<0.5		
	K6-01S	7.0		2.1	2.0		
	K6-19	0.5		<0.5	<0.5		

Table A-1. Pit 6 post-closure monitoring plan constituents of concern, detection monitoring wells, SLs, MCLs, and quarterly analytical results for 2012.

COC (units)	Well	SL	MCL	Quarter: First	Second	Third	Fourth
Volatile organic compounds (µg/L, EPA method 8260) (Cont.)							
Ethyl benzene	EP6-06	0.5	700	<0.5	<0.5		
	EP6-09	0.5		<0.5	<0.5		
	K6-01S	0.5		<0.5	<0.5		
	K6-19	0.5		<0.5	<0.5		
Methylene chloride	EP6-06	1	5	<1	<1		
	EP6-09	1		<1	<1		
	K6-01S	1		<1	<1		
	K6-19	1		<1	<1		
Tetrachloroethene	EP6-06	0.5	5	<0.5	<0.5		
	EP6-09	0.5		<0.5	<0.5		
	K6-01S	0.5		<0.5	<0.5		
	K6-19	0.5		<0.5	<0.5		
Toluene	EP6-06	0.5	150	<0.5	<0.5		
	EP6-09	0.5		<0.5	<0.5		
	K6-01S	0.5		<0.5	<0.5		
	K6-19	0.5		<0.5	<0.5		
1,1,1-trichloroethane	EP6-06	0.5	200	<0.5	<0.5		
	EP6-09	0.5		<0.5	<0.5		
	K6-01S	0.5		<0.5	<0.5		
	K6-19	0.5		<0.5	<0.5		
Trichloroethene (TCE)	EP6-06	0.5	5	<0.5	<0.5		
	EP6-09	17		7.6	6.8		
	K6-01S	1.5		<0.5	<0.5		
	K6-19	13		2.5	2.6		
Xylenes (total)	EP6-06	1	1,750	<1	<1		
	EP6-09	1		<1	<1		
	K6-01S	1		<1	<1		
	K6-19	1		<1	<1		

[a] California State Maximum Contaminant Level (MCL).

Table A-2. Pit 6 detection monitoring quarterly ground water physical parameters for 2012.

Detection well	Quarter 2012	Date sampled	GWE[a] (ft)	Temp. (ºC)	pH (pH units)	Specific conductivity (µmho/cm)	TDS[b] (mg/L)
EP6-06	Q1	Jan 9	659.38	20.0	7.11	1,306	860
EP6-06	Q2	Apr 11	660.98	18.1	7.69	1,229	880
EP6-06	Q3	Q3	–	–	–	–	–
EP6-06	Q4	Q4	–	–	–	–	–
EP6-09	Q1	Jan 5	664.10	21.2	8.13	5,432	1,400
EP6-09	Q2	Apr 11	663.20	20.9	7.76	1,687	1,200
EP6-09	Q3	Q3	–	–	–	–	–
EP6-09	Q4	Q4	–	–	–	–	–
K6-01S	Q1	Jan 5	664.07	21.8	7.19	3,863	2,400
K6-01S	Q2	Apr 11	664.29	21.5	7.12	3,718	3,000
K6-01S	Q3	Q3	–	–	–	–	–
K6-01S	Q4	Q4	–	–	–	–	–
K6-19	Q1	Jan 9	663.67	26.1	6.21	1,211	820
K6-19	Q2	Apr 11	663.57	19.5	7.72	1,996	780
K6-19	Q3	Q3	–	–	–	–	–
K6-19	Q4	Q4	–	–	–	–	–

[a] Ground water elevation (water table elevation in feet above mean sea level).

[b] Total dissolved solids.

Appendix B

Tables of Ground Water Measurements for Corrective Action Monitoring Wells

Table B-1. Water elevation (GWE) measurements in Pit 6 ground water monitoring wells, second quarter of 2012.

Well	Date sampled	GWE (ft above MSL)
BC6-10	11-Jun	657.1
BC6-13	11-Jun	DRY
CARNRW1	3-Apr	577.8
CARNRW1	31-May	586.9
CARNRW1	5-Jun	586.7
CARNRW3	3-Apr	650
CARNRW3	1-May	650.8
CARNRW3	31-May	650.8
CARNRW3	5-Jun	647.9
CARNRW4	2-Apr	637.6
CARNRW4	1-May	637.9
CARNRW4	31-May	639.4
CARNRW4	5-Jun	639.5
EP6-06	11-Apr	661
EP6-06	11-Jun	661.3
EP6-07	11-Jun	630.9
EP6-08	11-Jun	DRY
EP6-09	11-Apr	663.2
EP6-09	11-Jun	664
K6-01	11-Jun	663.8
K6-01S	11-Apr	664.3
K6-01S	11-Jun	663.9
K6-03	11-Jun	630.1
K6-04	11-Jun	642.5
K6-14	11-Jun	659.9
K6-15	11-Jun	DRY
K6-16	11-Jun	661.3
K6-17	2-Apr	657
K6-17	11-Jun	657.7
K6-18	11-Jun	659.8
K6-19	11-Apr	663.6
K6-19	11-Jun	663.5
K6-21	11-Jun	DRY
K6-22	2-Apr	645.1
K6-22	11-Jun	644.9
K6-23	2-May	657
K6-23	11-Jun	657.2
K6-24	11-Jun	DRY
K6-25	11-Jun	661.7
K6-26	11-Jun	631
K6-27	11-Jun	627.9

Table B-1. Water elevation (GWE) measurements in Pit 6 ground water monitoring wells, second quarter of 2012.

Well	Date sampled	GWE (ft above MSL)
K6-32	11-Jun	DRY
K6-33	11-Jun	630.3
K6-34	2-Apr	626
K6-34	11-Jun	619.5
K6-35	11-Jun	630.5
K6-36	11-Jun	651.7
W-33C-01	11-Jun	634.9
W-34-01	11-Jun	671.4
W-34-02	11-Jun	634.9
W-PIT6-1819	2-Apr	625.7
W-PIT6-1819	11-Jun	617.2

Table B-2. Volatile organic compounds detected in Pit 6 ground water samples, second quarter of 2012.

Analytical method	VOCs detected	Well	Date sampled	Type	Result (μg/L)
E8260	cis-1,2-Dichloroethene	K6-01S	Apr 11	RTN	2.0
E8260	1,2-Dichloroethene (total)	K6-01S	Apr 11	RTN	2.0
E8260	Trichloroethene	EP6-09	Apr 11	RTN	6.8
E8260	Trichloroethene	EP6-09	Apr 11	DUP	7.1
E8260	Trichloroethene	K6-19	Apr 11	RTN	2.6

Table B-3. Tritium activity measurements in Pit 6 ground water samples, second quarter of 2012.

Well	Date sampled	Routine or duplicate	Activity (pCi/L)	Activity (Bq/L)
CARNRW1	Apr 3	RTN	<100	<3.7
CARNRW1	Apr 3	DUP	<100	<3.7
CARNRW1	May 1	RTN	<100	<3.7
CARNRW1	May 1	DUP	<100	<3.7
CARNRW1	Jun 5	RTN	<100	<3.7
CARNRW1	Jun 5	DUP	<100	<3.7
CARNRW2	Apr 3	RTN	<100	<3.7
CARNRW2	Apr 3	DUP	<100	<3.7
CARNRW2	May 1	RTN	<100	<3.7
CARNRW2	May 1	DUP	<100	<3.7
CARNRW2	Jun 5	RTN	<100	<3.7
CARNRW2	Jun 5	DUP	<100	<3.7
CARNRW3	Apr 3	RTN	<100	<3.7
CARNRW3	Apr 3	DUP	<100	<3.7
CARNRW3	May 1	RTN	<100	<3.7
CARNRW3	May 1	DUP	<100	<3.7
CARNRW3	Jun 5	RTN	<100	<3.7
CARNRW3	Jun 5	DUP	<100	<3.7
CARNRW4	Apr 2	RTN	<100	<3.7
CARNRW4	Apr 2	DUP	<100	<3.7
CARNRW4	May 1	RTN	<100	<3.7
CARNRW4	May 1	DUP	<100	<3.7
CARNRW4	Jun 5	RTN	<100	<3.7
CARNRW4	Jun 5	DUP	<100	<3.7
EP6-06	Apr 11	RTN	<100	<3.7
EP6-06	Apr 11	DUP	<100	<3.7
EP6-09	Apr 11	RTN	<100	<3.7
K6-01S	Apr 11	RTN	112	4.1
K6-17	Apr 2	RTN	<100	<3.7
K6-19	Apr 11	RTN	230	8.5
K6-22	Apr 2	RTN	<100	<3.7
K6-34	Apr 2	RTN	<100	<3.7
W-PIT6-1819	Apr 2	RTN	156	5.8

Table B-4. Perchlorate and nitrate concentrations in Pit 6 ground water samples, second quarter of 2012.

Well	Date sampled	Routine or duplicate	Perchlorate (µg/L)	Nitrate (as NO3) (mg/L)
CARNRW1	3-Apr	RTN	<4	<0.5
CARNRW1	3-Apr	DUP	<4	<0.5
CARNRW1	1-May	RTN	<4	<0.5
CARNRW1	1-May	DUP	<4	<0.5
CARNRW1	5-Jun	RTN	<4	<0.5
CARNRW1	5-Jun	DUP	<4	<0.5
CARNRW2	3-Apr	RTN	<4	0.9
CARNRW2	3-Apr	DUP	<4	0.6
CARNRW2	1-May	RTN	<4	2.9
CARNRW2	1-May	DUP	<4	1.7
CARNRW2	5-Jun	RTN	<4	2.1
CARNRW2	5-Jun	DUP	<4	1.7
CARNRW3	3-Apr	RTN	<4	<0.5
CARNRW3	3-Apr	DUP	<4	<0.5
CARNRW3	1-May	RTN	<4	<0.5
CARNRW3	1-May	DUP	<4	<0.5
CARNRW3	5-Jun	RTN	<4	<0.5
CARNRW3	5-Jun	DUP	<4	<0.5
CARNRW4	2-Apr	RTN	<4	0.7
CARNRW4	2-Apr	DUP	<4	<0.5
CARNRW4	1-May	RTN	<4	<0.5
CARNRW4	1-May	DUP	<4	<0.5
CARNRW4	5-Jun	RTN	<4	<1
CARNRW4	5-Jun	DUP	<4	<0.5
EP6-06	11-Apr	RTN	<4	<0.5
EP6-06	11-Apr	DUP	<4	<0.5
EP6-09	11-Apr	RTN	<4	9.3
K6-01S	11-Apr	RTN	<4	<2.5
K6-19	11-Apr	RTN	<4	<2.5

Table B-5. Pit 6 monitoring locations, monitoring functions, associated monitoring programs, COCs, monitoring frequencies, and second quarter 2012 sampling summary.

Monitoring location	Monitoring function	Monitoring program	COCs[a] (sampling frequency)	COCs analyzed	Reason(s), if not completed
K6-17	guard well	CAMP	P (Q), S (SA)	P	
K6-22	guard well	CAMP	P (Q), S (SA)	P	
K6-34	guard well	CAMP	P (Q), S (SA)	P	
W-PIT6-1819	guard well	CAMP	P (Q), S (SA)	P	
SPRING15	plume tracking spring	CAMP	P (B), S (B)	none	Not scheduled
BC6-10	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
BC6-13	plume tracking well	CAMP	P (B), S (B)	none	Not scheduled
EP6-07	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-01	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-03	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-04	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-14	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-15	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-16	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-18	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-21	plume tracking well	CAMP	P (A), S (A)	none	Not scheduled
K6-23	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-24	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-25	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-26	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-27	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-32	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-33	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
K6-35	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
W-33C-01	plume tracking well	CAMP	P (SA), S (A)	none	Not scheduled
EP6-06	release detection well	DMP	All (Q)	All	
EP6-08	release detection well	DMP	All (Q)	none	DRY
EP6-09	release detection well	DMP	All (Q)	All	
K6-01S	release detection well	DMP	All (Q)	All	
K6-19	release detection well	DMP	All (Q)	All	
K6-36	release detection well	DMP	All (Q)	none	DRY
CARNRW1	water supply well	CAMP	P (M), S (M)	P,S	
CARNRW2	water supply well	CAMP	P (M), S (M)	P,S	
CARNRW3	water supply well	CAMP	P (M), S (M)	P,S	
CARNRW4	water supply well	CAMP	P (M), S (M)	P,S	

[a] "P" = primary contaminants of concern-tritium and VOCs. "S" = secondary contaminants of concern-perchlorate and nitrate. "All" = all DMP constituents of concern (see **Table C-1** for a list). "(M)" = sampled monthly. "(Q)" = sampled quarterly. "(SA)" = sampled semiannually (done first and third quarters of year). "(A)" = sampled annually (done first quarter of year). "(B)" = sampled biennially (done first quarter of year).

Appendix C

Statistical Methods for Detection Monitoring

Appendix C

Statistical Methods for Detection Monitoring

Monitoring and reporting provisions of the CERCLA closure and post-closure plan for the Pit 6 landfill require the use of statistical methods from the *California Code of Regulations* (CCR) Title 23, Division 3, Chapter 15, Section 2550.7 (Ferry et al., 1998).

We use statistically determined limits of concentration (SLs) to detect potential releases of constituents of concern to ground water from solid wastes contained in the Pit 6 landfill. We employ two statistical methods, prediction intervals (PIs) and control charts (CCs), to generate SLs. Both methods are sensitive to constituents of concern concentration increases. Both methods are cost-effective, requiring only one measurement of a constituent of concern per quarter per monitoring well.

We prefer the PI method when constituents of concern concentrations in ground water are similar up-gradient and down-gradient from the monitored unit. We use parametric PI methods when the up-gradient constituent of concern concentration data are all above the detection limit and the data are approximately normally distributed. We may use parametric methods on log-transformed data, if the transformed data follow a normal distribution. Nonparametric PI methods are more effective when the data cannot be transformed to a normal distribution, or when they contain nondetections.

When the concentration of a constituent of concern is spatially variable in the vicinity of a monitored unit, we develop a control chart for each down-gradient monitoring well. The control chart compares each new quarterly constituent of concern measurement with its concentration history for that well.

Wherever sufficient historical detections exist, we calculate an SL such that any future measurement has approximately a 1-in-100 chance of exceeding the SL, when no change in concentration has actually occurred. This yields a statistical test with a significance level of approximately 0.01. Where historical detections exist, but non-detections constitute part of the data, we set the SL equal to the highest concentration measured. If historical analyses of a constituent of concern show all non-detections, then we set the SL equal to the analytical reporting limit (RL). When a routine constituent of concern measurement exceeds an SL, we perform two discrete retests. This method of data verification is in accordance with CCR Title 23, Chapter 15, Section 2550.7.

Constituents of Concern

Constituents of concern were identified for monitoring in the ground water at the Pit 6 landfill prior to its closure (Ferry et al., 1998). Constituents of concern, as defined by CCR Title 22, Chapter 15, are waste constituents, their reaction products, or hazardous constituents that are reasonably expected to be in or derived from waste buried in Pit 6. The current constituents of concern for Pit 6 are listed in **Table C-1** below.

Table C-1. Pit 6 constituents of concern, typical analytical reporting limit (RL), concentration limit (CL)[a], and statistical limit (SL) for each of the six detection monitoring wells.

Constituent of concern	Typical analytical RL (units)	Well EP6-06 CL; SL	Well EP6-08 CL; SL	Well EP6-09 CL; SL	Well K6-01S CL; SL	Well K6-19 CL; SL	Well K6-36 CL; SL
1,1,1-TCA	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
1,2-DCA	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Cis-1,2-DCE	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	5.4; 7.0	<RL; RL	<RL; RL
Chloroform	0.5 µg/L	<RL; RL	0.1; 1.0	<RL; RL	<RL; RL	0.2; 1.5	<RL; RL
Methylene chloride	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
PCE	0.5 µg/L	<RL; RL	0.4; 1.6	<RL; RL	<RL; RL	<RL; RL	0.5; 1.0
TCE	0.5 µg/L	<RL; RL	<RL; RL	14; 17	1.1; 1.5	8.2; 13	0.8; 2.1
Benzene	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Ethylbenzene	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Toluene	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Total xylenes	1.0 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Beryllium	0.5 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Mercury	0.2 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Carbon disulfide	5.0 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL
Perchlorate	4.0 µg/L	<RL; RL	<RL; RL	<RL; RL	<RL; RL	10.2; 27.5	5.3; 14.4
Tritium	100 pCi/L	RL; RL	<RL; RL	<RL; RL	<RL; RL	<RL; RL	2060; 2390
Uranium (total)	0.5 pCi/L	1.9; 3.6	1.2; 1.5	2.1; 3.7	6.6; 27	3.2; 7.2	0.5; 1.4
Gross alpha [b]	2 pCi/L	2.7; 7.7	0.9; 4.0	1.0; 4.9	7.0; 26	2.0; 9.2	<RL; RL
Gross beta [b]	2 pCi/L	8.6; 21	8.6; 21	8.6; 21	14; 58	8.6; 21	9.8; 26

[a] CL (concentration limit) is equivalent to the background concentration of a COC.
[b] Gross alpha and gross beta are surrogates for ^{125}Sb, ^{137}Cs, ^{60}Co, ^{22}Na, ^{90}Sr, ^{204}Tl, and ^{232}Th.

Chlorinated VOCs (including TCE, PCE, 1,2-DCA, 1,1,1-TCA, methylene chloride, chloroform, benzene, toluene, ethylbenzene, and total xylenes) were detected historically in ground water and/or in soil adjacent to Pit 6. These VOCs are constituents of concern.

Beryllium and mercury are constituents of concern because they are listed in the waste disposal records for Pit 6.

Nine radionuclide constituents of concern are associated with waste buried in Pit 6. They are ^{125}Sb, ^{137}Cs, ^{60}Co, ^{22}Na, ^{90}Sr, ^{204}Tl, ^{232}Th, ^{238}U, and tritium. Gross alpha and gross beta radioactivity are used as surrogates for seven of these nuclides, but not for uranium and tritium, which are measured separately (**Table C-1**).

A minor tritium release occurred prior to closure of Pit 6 and is the object of a continuing LLNL CERCLA investigation. The detection monitoring well BC6-12 was destroyed during year 2000 because it was screened across two water-bearing zones and could have provided a conduit for tritium in the shallower zone to contaminate ground water in the deeper zone. Well BC6-12 was replaced by well K6-36, which was constructed adjacent to it. Well K6-36 is screened only in the shallow water-bearing zone. Our calculated constituent of concern SLs for replacement well K6-36 are shown in **Table C-1**.

A post-closure LLNL CERCLA study detected perchlorate in ground water down-gradient of Pit 6. Consequently, perchlorate was added to the constituent of concern list and SLs for this chemical have been calculated (**Table C-1**).

Pesticides were not detected over an 18-month period (6 quarterly sampling events) following pit closure and were removed from the constituents of concern list.

Phthalates were not designated as constituents of concern because they were rarely detected prior to pit closure. However, since post-closure monitoring began in 1998, we have detected bis(2-ethylhexyl)phthalate (also known as di[2-ethylhexyl]phthalate, or DEHP) in ground water both up-gradient and down-gradient from Pit 6.

Table C-2 lists constituents of concern that have indicated statistically significant evidence of release to ground water since post-closure monitoring began in 1998. **Table C-2** also lists the date of our 7-day letter notification to the CVRWQCB and the status of any additional investigation of the constituent of concern. Note that 1,2-DCA has not been detected since 1998.

Table C-2. Pit 6 constituents of concern showing statistical evidence of post-closure release.

Constituent of Concern	Date of 7-day letter report	Status of release investigation
1,2-DCA	10/13/98[a]	Transferred to ERD[b]
TCE	09/11/07[c]	Transferred to ERD[b]
Uranium	02/21/08[d]	Transferred to ERD[b]

[a] Galles, H. L., to S. Timm (1998), Letter: *Statistically Significant Evidence for a Release of 1,2-Dichloroethane from Pit 6* (WGMG98:282, October 13, 1998).
[b] LLNL Environmental Restoration Department.
[c] Goodwin,S., to S. Timm (2007), Letter: *Statistically Significant Evidence for a Release of Trichloroethene (TCE) from Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 6* (WGMG07-109, September 11, 2007).
[d] Jackson, C.S., to S. Timm (2007), Letter: *Statistically Significant Evidence for a Release of Total Uranium from Lawrence Livermore National Laboratory Experimental Test Site (Site 300) Pit 6* (WGMG08-022, February 21, 2008).

Appendix D

Changes in Monitoring Programs or Methods

Appendix D

Changes in Monitoring Programs or Methods

LLNL implemented a compliance monitoring program during the second quarter of 1998 for the CERCLA-closed Pit 6 landfill at Site 300. The program is described in detail in Ferry et al., 1998.

During 2000, two new monitoring –wells, designated K6-35 and K6-36, replaced monitoring wells BC6-11 and BC6-12, which were destroyed by grouting. Well K6-36, which is screened in the first (shallower) of two water-bearing zones, replaced well BC6-12 for re–lease detection. Well K6-35, screened in the next deeper water-bearing zone, is used for corrective-action assessment.

By request of the CVRWQCB, perchlorate was added to the list of Pit 6 constituents of concern during the third quarter of 2000.

By request of the CVRWQCB, since the third quarter of 2000, a table of information (**Table B-5**) has been provided that lists the Pit 6 CERCLA monitoring wells, their monitoring program assignments, their sampling frequencies, the constituents of concern they monitor, and a reason if they were not sampled during the reported quarter.

During 2001, quarterly tritium monitoring was expanded to include CERCLA well K6-33 and the private, off-site water-supply wells designated CARNRW1 and CARNRW2. During 2002, a new CERCLA guard well was completed downgradient from Pit 6 adjacent to the Site 300 boundary. This well is identified as W-PIT6-1819.

Beginning January 1, 2003, the CAMP sampling schedule and constituents of concern have changed as described in the *Compliance Monitoring Plan/Contingency Plan for Interim Remedies at Lawrence Livermore National Laboratory, Site 300* (Ferry, et al., 2002). An expanded set of CAMP wells and springs will be sampled semiannually for tritium and VOCs, and annually for nitrate and perchlorate, while DMP well monitoring remains essentially unchanged. However, upgradient wells K6-03, K6-04, K6-15, and K6-32, which were formerly sampled quarterly for all the DMP constituents of concern listed in **Table C-1**, are now designated to be CAMP plume-tracking wells and are sampled semiannually for tritium and VOCs and annually for nitrate and perchlorate only. As of the fourth quarter of 2004, VOCs have been reported as Total VOCs (TVOCs) to be consistent with other reports.

During 2006, reporting limits provided by the analytical laboratory for U.S. Environmental Protection Agency (EPA) Methods 200.8:Be, 601, and 624 changed due to a transition of the contract laboratory's data management system. Essentially, the analytical laboratory had agreed to provide detection limits for EPA Methods 601 and 624, which were the same as EPA Method 8260. However, after the data management system change, the labs began reporting only what was specified in our contracts. As a result of this change in practice, the revisions have affected the reported non-detect concentrations for the following constituents of concern: beryllium, benzene, chloroform, 1,2-dichloroethane (cis-1,2-DCE), cis-1,2-dichloroethene, ethylbenzene, PCE, toluene, 1,1,1-trichloroethane, and total xylenes. In all these cases, the different reporting limits represent practical quantitation limits (PQLs) selected by the analytical laboratory, not a change in measured concentrations. LLNL examined if contract modifications, changes in analytical suites, or a change of method would best solve the problem. Starting in the second quarter of 2007, we began reporting VOCs measured with EPA method 8260 and metals with the WGMGMET3 metal contract suite, which provides detection limits consistent with, or lower than, past reports. No changes to this monitoring plan were made during this reporting period.

In July 2012, DOE/LLNL proposed and the regulatory agencies agreed to modify the detection monitoring and reporting program for the Pit 6 Landfill for consistency with the Detection Monitoring Program in the CERCLA Site-Wide Compliance Monitoring Plan. As part of these regulatory-accepted changes, the U.S. Environmental Protection Agency, the California Department of Toxic Substances Control, and the Central Valley Regional Water Quality Control Board agreed that DOE/LLNL no longer needed to submit these quarterly Pit 6 Post-Closure Monitoring Report to eliminate redundancies with reporting in the semi-annual and annual Compliance Monitoring Reports. As a result, the regulators have concurred that this 2nd Quarter 2012 report will be the last quarterly report submitted for the Pit 6 Landfill. Pit 6 detection and corrective action monitoring results for the second semester of 2012 will be reported in the Annual 2012 Compliance Monitoring Report. Pit 6 detection and corrective action monitoring results in 2013 and thereafter will be reported in the Semi-Annual and Annual Compliance Monitoring Reports.

DOE/LLNL will submit an Addendum to the Compliance Monitoring Plan to incorporate the Pit 6 Detection Monitoring and Reporting Program, which will supercede the 1998 Post-Closure Monitoring Plan.

Appendix E

Quality Assurance Sample Results

Table E-1. Quality assurance samples from Pit 6 during the second quarter of 2012.

Constituent*	Units	EP6-06 Routine (Apr 11)	EP6-06 Duplicate (Apr 11)	EP6-09 Routine (Apr 11)	EP6-09 Duplicate (Apr 11)	PIT6FB Field blank (Apr 11)
Total dissolved solids (TDS)	mg/L	880	880	1200	-	<6.7
Beryllium	mg/L	<0.2	<0.2	<0.2	-	<0.2
Mercury	µg/L	<0.2	<0.2	<0.2	-	<0.2
Nitrate (as NO3)	µg/L	<0.5	<0.5	9.3	-	<0.5
Perchlorate	mg/L	<4	<4	<4	-	<4
1,1,1-Trichloroethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
1,1,2,2-Tetrachloroethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
1,1,2-Trichloroethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
1,1-Dichloroethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
1,1-Dichloroethene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
1,2-Dichloroethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
1,2-Dichloroethene (total)	µg/L	<1	<1	<1	<0.5	<1
1,2-Dichloropropane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
cis-1,2-Dichloroethene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
cis-1,3-Dichloropropene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
2-Butanone	µg/L	<10	<10	<10	<2	<10
2-Chloroethylvinylether	µg/L	<10	<10	<10	<1	<10
2-Hexanone	µg/L	<10	<10	<10	<1	<10
4-Methyl-2-pentanone	µg/L	<10	<10	<10	<1	<10
Acetone	µg/L	<10	<10	<10	<10	<10
Acrolein	µg/L	<50	<50	<50	<4	<50
Acrylonitrile	µg/L	<50	<50	<50	<2	<50
Benzene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Bromodichloromethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Bromoform	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Bromomethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Carbon disulfide	µg/L	<5	<5	<5	<1	<5
Carbon tetrachloride	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorobenzene	µg/L	<0.5	<0.5	<0.5	<1	<0.5
Chloroethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chloroform	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Chloromethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Dibromochloromethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Dichlorodifluoromethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Ethanol	µg/L	<1000	<1000	<1000	<500	<1000
Ethylbenzene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Freon 113	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Methylene chloride	µg/L	<1	<1	<1	<0.5	<1
Styrene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Tetrachloroethene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Total xylene isomers	µg/L	<1	<1	<1	<0.5	<1
trans-1,2-Dichloroethene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
trans-1,3-Dichloropropene	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Trichloroethene	µg/L	<0.5	<0.5	6.8	7.1	<0.5
Trichlorofluoromethane	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Vinyl acetate	µg/L	<20	<20	<20	<1	<20
Vinyl chloride	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Tritium	Bq/L	2.1 <U+00B1> 2.2	0.36 <U+00B1> 2.0	0.71 <U+00B1> 2.0	-	0.84 <U+00B1> 2.3
Gross alpha	Bq/L	0.033 <U+00B1> 0.049	0.060 <U+00B1> 0.050	0.090 <U+00B1> 0.056	-	-0.011 <U+00B1> 0.023
Gross beta	Bq/L	0.26 <U+00B1> 0.069	0.35 <U+00B1> 0.081	0.39 <U+00B1> 0.092	-	0.0068 <U+00B1> 0.034
Uranium (calculated total)	Bq/L	0.021 <U+00B1> 0.0048	0.035 <U+00B1> 0.0064	0.062 <U+00B1> 0.0075	-	0.00049 <U+00B1> 0.0013

(-)= Not analyzed.

Appendix F

LLNL Site 300 Pit 6 Cap Annual Engineering Inspection

Abri Environmental Engineering, Inc.

Environmental Management and Compliance Consultants

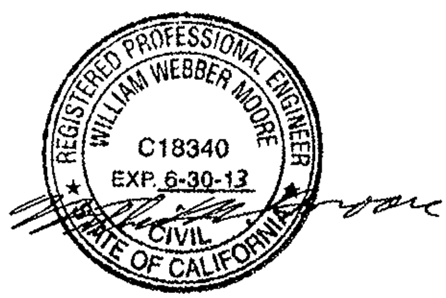
LLNL SITE 300 PIT 6 CAP ANNUAL ENGINEERING INSPECTION

May 2012

CERTIFICATION

Based on the information reviewed, I certify that this annual inspection and evaluation report fairly describes the condition of the closed Pit 6.

I certify under penalty of law that this document and all attachments were prepared in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of those persons directly responsible for gathering the information, the information is, to the best of my knowledge and belief, true, accurate, and complete.



William W. Moore, P.E.
California Civil Engineer, No. 18,340

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Executive Summary

Abri Environmental Engineering has performed the annual inspection of the Pit 6 Cap at the Lawrence Livermore National Laboratory (LLNL) Site 300 located near the City of Tracy. Mr. William W. Moore, P.E., conducted this annual inspection on May 2, 2012. Mr. Moore is a California Registered Civil Engineer, with extensive experience in civil engineering, and hazardous waste management.

This report has been prepared consistent with the scope of work dated March 19, 2012 and in compliance with 22CCR Section 66264.228(K). The report is based on the observations made during the inspection and review of the documents listed below.

Pit 6 cap is in good condition; the vegetation cover is thick and established. There is no visible erosion of the cap; and the drainage system is in good condition and appears to be functioning as intended. The groundwater monitoring system appears to be in good condition as well. Evidence of accumulation of vegetative debris in the concrete lined drainage ditch and several large borrowing animal holes were observed. Recommendations for the observations are made in section 2-14.

1.0 Introduction

LLNL Site 300, EPA ID Number CA2890090002, is owned by the U.S. Department of Energy (DOE) and is operated jointly by the Lawrence Livermore National Security, LLC (LLNS) and DOE. The Site comprises approximately 7,000 acres of largely undeveloped land and is primarily used as an explosives test facility. Site 300 is located 15 miles southeast of the LLNL Livermore Site, and 6 miles southwest of downtown City of Tracy, California, see Figure 1. About one-sixth of the site is in Alameda County and the balance is in San Joaquin County.

Pit 6 is located in the southwest corner of Site 300 near Corral Hollow Road, see Figure 2. The Pit was used to dispose of solid wastes and animal carcasses. The solid wastes primarily consisted of laboratory materials and equipment, tanks, capacitors, and pallets. The animal carcasses included small animals used in biomedical experiments. The wastes were contaminated with radioactivity, volatile organic compounds and metals, among other contaminants.

The pit was used between 1964 and 1973 and was closed in 1997 under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) oversight. The closure activities occurred under US EPA, California

Department of Toxic Substances Control (DTSC), and Regional Water Quality Control Board (RWQCB). The closure consisted of leaving the waste in place and installing at least a 6 ft thick cap over the pit. The cap consists of a two ft minimum pre-existing cover, two ft thick compacted foundation layer, a geosynthetic, low permeability clay liner, a 60-mil HDPE liner, a geocomposite drainage layer/biotic barrier, two ft of topsoil, and vegetative layer. A drainage ditch and trench system were installed to remove run-off and divert water from the pit.

The inspection of the cap included walking the surface and perimeter of the cap. Weather conditions were sunny, temperatures in high 60's degrees F with winds 5-10 miles per hour.

In conjunction with the inspection, the following project files and documents were reviewed:

- Post-Closure Plan for the Pit 6 Landfill Operable Unit, Lawrence Livermore National Laboratory, Site 300, May 18, 1998.
- Annual Pit Survey Data from 1998 to 2011,
- Post-Closure Inspection Checklists dated January 17, 2012.

Currently, a portion of the cap area is used for a rifle range. The facilities consist of a small building, a rifle area and 3 mounded target areas.

2.0 Inspection Observations and Recommendations

The following sections describe the condition and recommendations.

2-1. *Condition of Access Control (Fences, Gates and Warning Signs)*

LLNL Site 300 is a highly secured site with around the clock armed guards and perimeter fence. The entrance to the site is on Corral Hollow Road, which is secured by gates, fences and armed guards. Warning signs in English are posted adjacent to the pit, see Figure 3.

2-2 *Condition of Vegetation*

The cap was covered with well-established and thick vegetation, see Figure 4.

2-3 *Erosion*

No erosion was observed during the site visit.

2-4 *Cracking*

No cracking or other desiccation of the cover was visible during the site visit.

2-5 *Disturbance by Adverse Weather*

No erosion or other evidence of disturbance/damage due to adverse weather (i.e. freezing and thawing) was observed at the site.

2-6 *Seepage*

No evidence of seepage or discharge was observed beyond the existing collection structures at the facility.

2-7 *Slope Stability*

No indication of slope instability was observed. There were no signs of sloughing or slumping.

2-8 *Subsidence*

No evidence of subsidence was observed over the pit.

2-9 *Settlement*

Results of the annual pit survey data from 1998 to 2011 showed maximum settlement of 0.17 feet.

2-10 *Condition of Groundwater Monitoring System*

No evidence of compromise in structural integrity of the groundwater monitoring wells was observed.

2-11 *Condition of Run-On and Run-Off Control Systems*

Surface runoff diversion structures consist of a perimeter drainage ditch on three sides, and a relatively large riprap lined drainage along the north side. The structure also collects water from the "drainage layer" of the cap through a series of drainage pipes. Concrete lining appeared to be in good condition.

Vegetative debris was observed in the concrete lined drainage ditch. It is recommended that the vegetation be removed.

2-12 *Condition of Surveyed Benchmarks*

No settlement markers were observed during the inspection due to the vegetative cover. However, the LLNL surveyors confirmed that of the 22 markers 20 were present during the last survey in 2011. The surveyors' report does not include data for settlement markers B-5 and C-1.

2-13 *Burrowing Animals*

Several relatively large, approximately 8 to 12 inches in diameter, borrowing animals holes were observed, see figures 5 and 6. It is recommended that holes exceeding 6 in. in diameter be repaired.

2-14 List of recommendations for Pit 6

- Remove vegetation debris from the drainage ditch.
- Fill in the animal holes exceeding 6 in. in diameter.

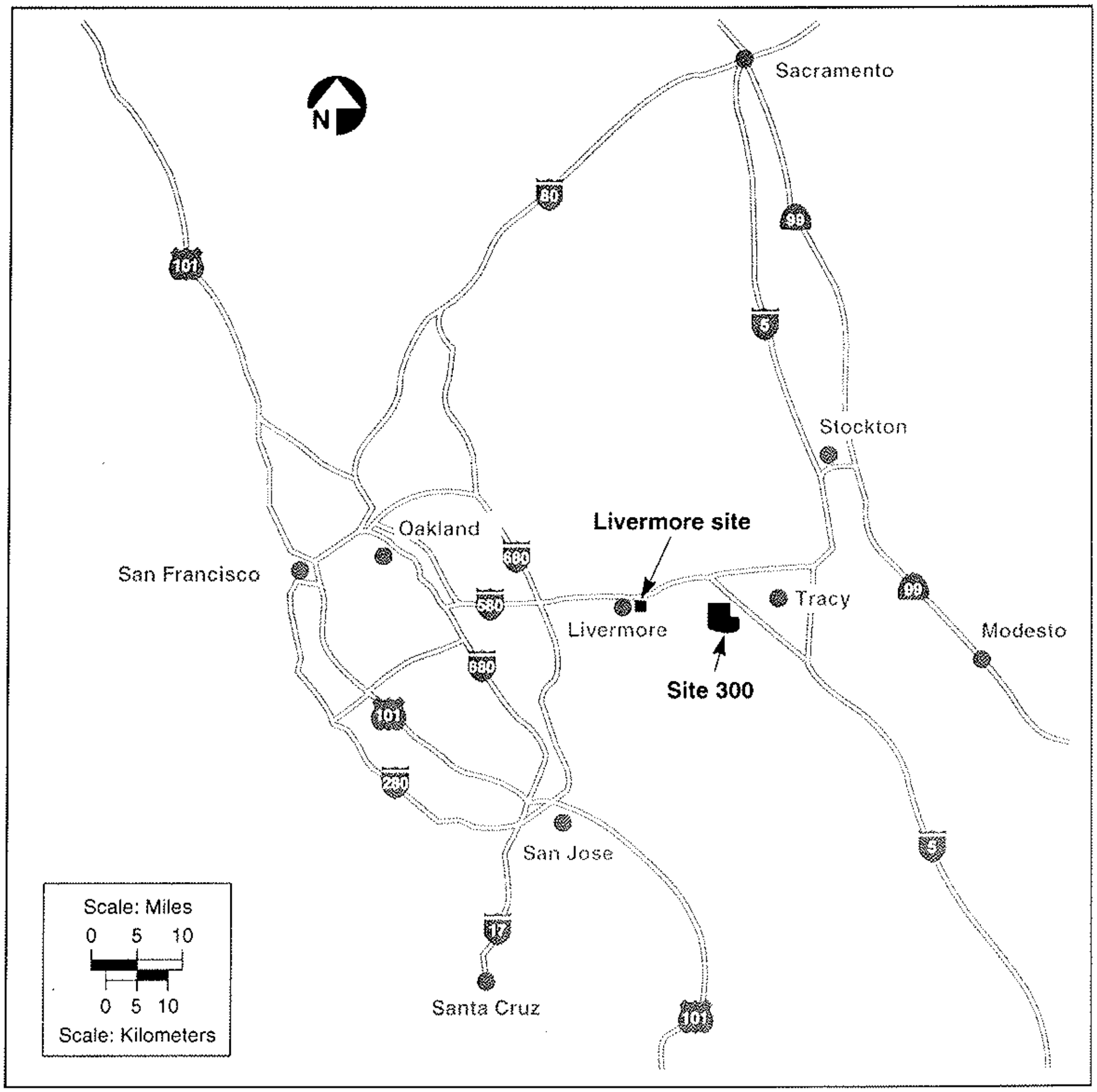

Figure 1 LLNL Location Map

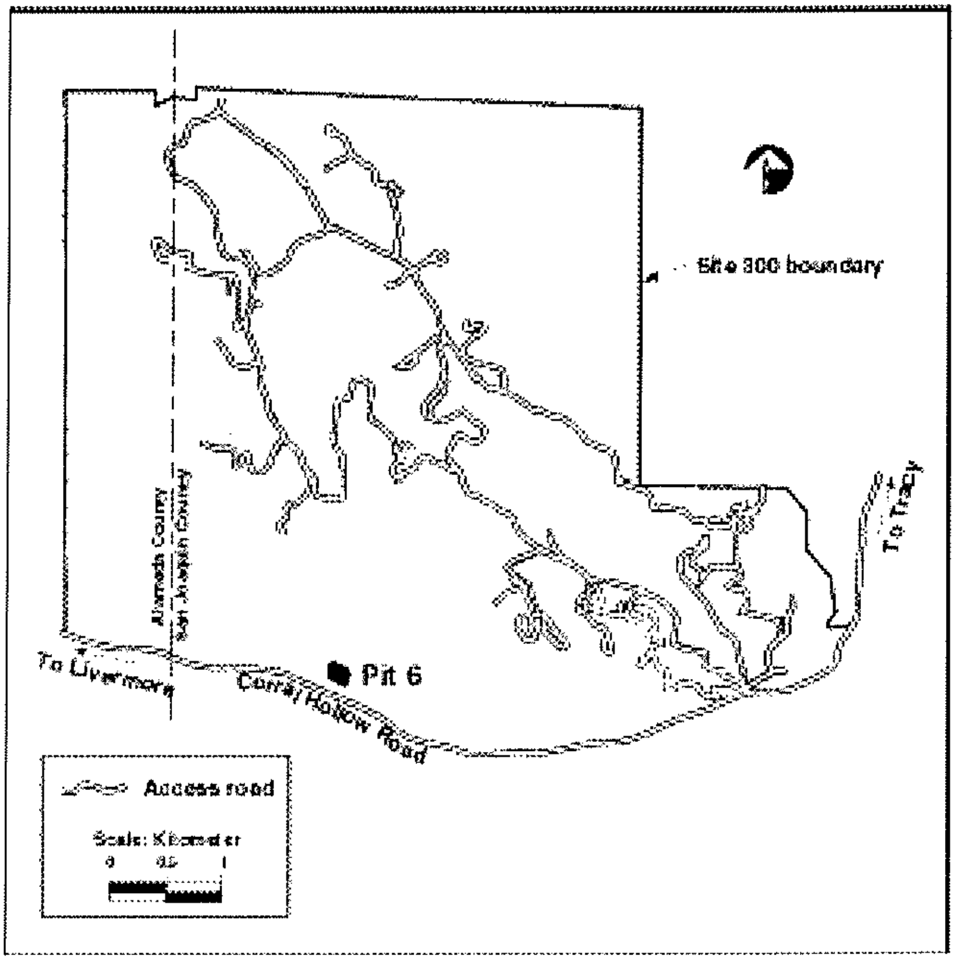

Figure 2 Pit 6 Location Map

Figure 3 **Pit 6 Warning Signs**

Figure 4 **Pit 6 Vegetation Cover Condition**

Figure 5 Pit 6 Borrowing Animal Hole

Figure 6 Pit 6 Borrowing Animal Hole

Environmental Functional Area, Lawrence Livermore National Laboratory
P.O. Box 808, L-627, Livermore, California 94551